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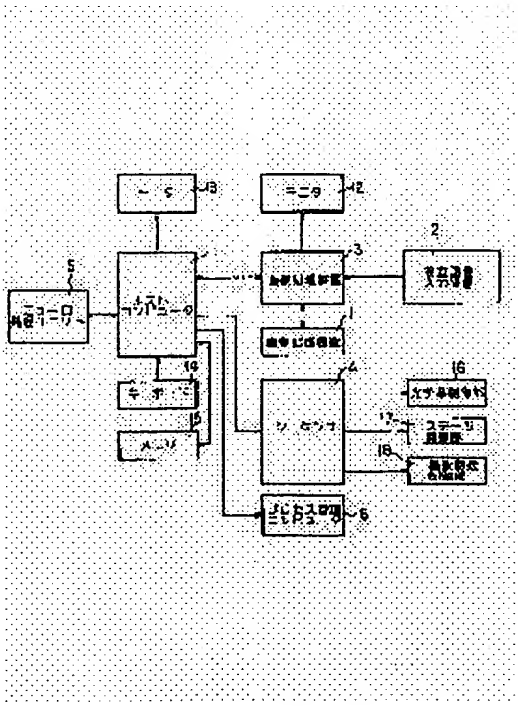
## (54) DEFECT TYPE JUDGING DEVICE AND PROCESS CONTROL SYSTEM

(57)Abstract:

PURPOSE: To provide a defect type judging device capable of automatically judging the defect type of a specimen and quickly and correctly feeding back the inspected result.

CONSTITUTION: This defect type judging device judges the type of each defect found in the defect inspection of a specimen, and it is provided with a neuro- processing unit 5 converting an input pattern into an optional output pattern. The neuro-processing unit 5 learns various defect types in advance so that the output pattern indicating an optional defect type is obtained from the input pattern of the defect information corresponding to each defect type. The defect information of the defect detected in the defect inspection is inputted to the neuro-processing unit 5, and the type of the defect is determined from the output pattern.



* NOTICES *



1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

## DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention relates to the defective classification judging equipment for judging the classification of the defect detected by the surface analysis of an analyte, or the process control system which performs process control based on a defective classification judging result in the manufacture process line of analytes, such as a semiconductor wafer or a liquid crystal glass substrate.
[0002]
[Description of the Prior Art] For example, in photograph lithography process lines, such as a liquid crystal panel, the defect by thickness unevenness of a resist, adhesion of dust, etc. which were applied to the substrate front face appears as the poor line breadth of a pattern, the pinhole in a pattern, etc. being poor after etching. Then, if a substrate is inspected and a defect is generally before etching, it will have prevented beforehand that a substrate with a defect goes into an etching process as it is by removing the substrate. These people have proposed suitable floodlighting equipment to inspect visually the defect on the front face of a substrate in Japanese Patent Application No. No. 31922 [ four to ]. The inspection by viewing of such an operator has the inspection capacity which was excellent compared with a mechanical inspection.
[0003]
[Problem(s) to be Solved by the Invention] However, in an operator's visual inspection, dispersion arises on inspection level by the difference in an operator's individual differences or observation environment, and there is a problem that inspection quality is not fixed. Although defatigation of an operator will increase if a visual inspection attains to many times and a long time, inspection quality may stop moreover, being fixed with an operator's fatigue.
[0004] Moreover, the defective pattern discovered by the visual inspection mentioned above was guessing the cause of defective etc. from the content of processing of its experience or a manufacture process, after the operator observed the defect in detail under the microscope, since it changed with the process which the defect generated, or defective generating causes of a there. However, in order to go across the examination item which should be examined in case a defective generating process and a defective generating cause are guessed variably, in it having been dependent on an operator's judgment, it was difficult to trace a defective generating process quickly and to take an effective cure.
[0005] Thus, it was difficult to specify a defective generating process and a defective generating cause quickly and correctly while conventional surface-discontinuity test equipment had the large burden concerning an operator, since inspection quality was not fixed since it depended on an operator's visual inspection, and the operator was guessing the defective generating process and the defective generating cause based on experience from the inspection result.
[0006] this invention was made in view of the above actual condition, can judge automatically the classification of the defect which related to the defective generating process or the defective generating cause closely, without depending on experience of the skilled operator, and aims at providing a manufacture process with the defective classification judging equipment and the process control system

which can be fed back for a defective inspection result quickly and correctly.
[0007]
[Means for Solving the Problem] this invention provided the following meanses, in order to attain the above-mentioned purpose. In the defective classification judging equipment which judges the classification of each defect in which this invention corresponding to a claim 1 was discovered by defective inspection of an analyte It has the neuro-processing unit which changes a certain input configuration into arbitrary output patterns. The aforementioned neuro-processing unit is made to learn so that the output pattern in which respectively arbitrary defective classification is shown to each defective information on the input configuration corresponding to each defective classification may appear. It constituted so that the defective information on the defect detected by the aforementioned defective inspection might be inputted into the aforementioned neuro-processing unit and the output pattern might determine defective classification.
[0008] The surface-discontinuity test equipment which generates the defective information about the defect concerned while extracting the defect of the aforementioned analyte, when this invention corresponding to a claim 2 carries out the image processing of the inspection picture of the analyte incorporated through predetermined optical system, It is beforehand learned so that the output pattern in which respectively arbitrary defective classification is shown to each defective information on the input configuration corresponding to each defective classification may appear. The neuro-processing unit which outputs the output pattern in which the defective classification is shown when the aforementioned defective information inputs from the aforementioned surface-discontinuity test equipment, It considered as the composition possessing the process control unit which controls the manufacture process of the aforementioned analyte based on the defective classification information on the aforementioned analyte judged in the aforementioned neuro-processing unit.
[0009] In the defective classification judging equipment of the above-mentioned composition, this invention corresponding to a claim 3 was constituted so that the defective information on a data structure that it has the information chosen from the kind of optical system which incorporates the area of a defect, the configuration of a defect, the position of a defect, the luminosity of a defect, and an analyte image to the aforementioned neuro-processing unit, and the kind of analyte might input.
[0010] In the defective classification judging equipment of the above-mentioned composition, this invention corresponding to a claim 4 was constituted so that the false defect extracted as a defect by the image processing of an inspection picture although it is not a defect might be learned by the aforementioned neuro-processing unit.
[0011] the aforementioned defective classification information that this invention corresponding to a claim 5 was judged in the aforementioned neuro-processing unit in the defective classification judging equipment of the above-mentioned composition -- accumulating -- and -- statistical -- processing -- prior prediction of defective generating -- a line -- it constituted like
[0012]
[Function] this invention does the following operations so by having provided the above meanses. According to this invention corresponding to a claim 1, a neuro-processing unit is beforehand learned so that it may become the output pattern in which respectively arbitrary defective classification is shown to the input configuration of each defective information corresponding to each defective classification. Thus, if the defective information about a certain defect is inputted into the learned neuro-processing unit, the output pattern corresponding to the input configuration of the defective information will be outputted. Since the neuro-processing unit is learned so that the output pattern in which the classification of each defect is shown to the input configuration of various defects may be outputted, this output pattern will express defective classification.
[0013] According to this invention corresponding to a claim 2, the inspection picture of an analyte is incorporated through predetermined optical system to surface-discontinuity test equipment. In surface-discontinuity test equipment, if a defect is detected by the image processing from an inspection picture, defective information, such as a configuration about the defect and a size, will be created. This defective information is inputted into a neuro-processing unit.

[0014] On the other hand, a neuro-processing unit is beforehand learned so that it may become the output pattern in which respectively arbitrary defective classification is shown to the input configuration of each defective information corresponding to each defective classification. Thus, if defective information inputs into the learned neuro-processing unit from surface-discontinuity test equipment, the output pattern in which the defective classification is shown will be outputted. The defective classification information which consists of an output pattern of a neuro-processing unit is sent out to a process control unit.
[0015] In a process control unit, control is applied to the manufacture process of an analyte based on the defective classification information on a defect that it is inputted from a neuro-processing unit. For example, the process is stopped or control of returning the analyte which specified the process which the defect generated and had the defect to reprocessing steps is attained.
[0016] According to this invention corresponding to a claim 3, various defective classification is learned using defective information, such as a kind of optical system with which a neuro-processing unit incorporates the area of a defect, the configuration of a defect, the position of a defect, the luminosity of a defect, and an analyte image, and a kind of analyte. Therefore, the defective classification which corresponds by inputting the defective information which consists of these examination items can be made to output.
[0017] Since according to this invention corresponding to a claim 4 the neuro-processing unit is beforehand learned so that the output pattern in which a false defect is shown to the defective information on a certain input configuration may be outputted, in an image processing technique, discernment can distinguish a difficult false defect certainly.
[0018] According to this invention corresponding to a claim 5, the defective classification information judged in the neuro-processing unit is accumulated serially, these defective classification information is processed statistically, and prior prediction of defective generating is performed.
[0019]
[Example] Hereafter, the example of this invention is explained. Drawing 1 is drawing showing functional block of the system which performs from defective inspection of an analyte to management of a manufacture process. this example is equipped with a host computer 1, the inspection picture input device 2, the image processing system 3, the sequencer 4, the neuro-processing unit 5, and the process control computer 6 grade.
[0020] The inspection picture input device 2 is equipped with the lighting optical system which consists of an interference optical system, diffraction optical system, slanting lighting optical system, etc., and the image pck-up optical system which carries out image formation of the inspection picture of an analyte on image pck-up elements, such as CCD, as shown in drawing 3 . The inspection picture of an analyte is incorporated by the inspection picture input device 2.
[0021] It connects with the inspection picture input device 2, and the image processing system 3 is equipped with the image-processing function to detect the kind of defect which extracted and extracted the defects (for example, "thickness unevenness", "dust", etc.) of an analyte from the inspection picture to input, a number, a position, area, etc. A part of defective information which these inspection items mention later is constituted. The picture storage 11 and the TV monitor 12 are connected to this image processing system 3.
[0022] A host computer 1 inputs into the neuro-processing unit 5 the defective information inputted from an image processing system 3, and sends out the defective name information outputted from the neuro-processing unit 5 to the process control computer 6 while it manages system-wide operation. Moreover, a host computer 1 is equipped with the function for it to be outputted from the neuro-processing unit 5, to accumulate a defective name serially, and to perform prior prediction of defective generating. The TV monitor 13, a keyboard 14, and memory 15 are connected to this host computer 1. As for memory 15, the verification condition (a setup of optical system and conditions of an image processing) for every kind of analyte, inspection data, etc. are saved.
[0023] The optical control section 16, the stage control section 17, and the substrate transfer-control section 18 are connected, and a sequencer 4 controls these control sections in response to the directions

from a host computer 1.
[0024] The neuro-processing unit 5 is a hardware unit made by consisting of two or more interlayers (the case where the number of interlayers is two being shown in this drawing) formed between an input layer, an output layer, and an input layer and an output layer, and imitating the structure of a nerve cell (neuron), as shown in drawing 2 . All the neurons of an input layer are connected to all the neurons of the 1st adjoining interlayer, and all the 1st interlayer's neurons are connected to all the 2nd interlayer's neurons. All the 2nd interlayer's neurons are connected to all the neurons of an output layer. And the weighting factor is set up between each neuron connected mutually. Generally it calls it study to adjust a weighting factor so that arbitrary output patterns may be outputted to the input configuration (input condition) given to the input layer. The output pattern wished to have to a specific input configuration can be made to output by repeating this number of times of study now. Such learning algorithm is called back propagation algorithm.
[0025] The detail of the data structure of the defective information impressed to the input layer of the neuro-processing unit 5 is shown in drawing 2 . Although this defective information was not illustrated [ the area of a defect, the configuration (Ferre) of a defect the center-of-gravity position (X address, Y address) of a defect, the kind (measurement conditions) of optical system, the luminosity of a defect, the image-processing method in an image processing system 3, and ], it consists of a kind of analyte, and a configuration of a defect (circularity, boundary length, etc.). Each item which constitutes defective information is expressed with the predetermined number of bits, respectively.
[0026] Here, although the area of a defect inputs the pixel size of a defective part by the binary, when dividing and inputting the size of area into smallness into size, there should just be 2 bits of input layers of the neuro-processing unit 5. The center-of-gravity position (X address, Y address) of a defect has also inputted position data by the binary. Moreover, since the defective method of detection changes according to the kind of analyte or a detectable defective content changes, the kind (measurement conditions) of optical system is expressed with 2 bits. In order that a defect may carve whether it is a white defect and whether it is a black defect, it is made to input the luminosity data of the defect expressed with 2 bits. Moreover, the image-processing method is expressed with the triplet, in order to judge the content of processing of a detection defect like the processing for the processing for small nonuniformity detection, and crack detection, the processing for big nonuniformity detection, and. Although the kind of analyte amounts to hundreds of kinds, such as size, a process, and a kind, since the process out of which the same defect comes was decided to some extent, it is expressed with 6 bits.
[0027] Moreover, a large number [ the kind of defect generated in the manufacture process of a liquid crystal substrate / a poor resist application, poor exposure, poor development, a crack, dust, etc. ]. The classification of these defects is expressed with the defective name of Defect A - Defect J. Dozens of kinds of defective names exist in fact. Moreover, although it is not a defect, when an image processing system 3 detects, there is a false defect which will be judged to be a defect. The classification of these false defects is expressed with the false defect A - the false defect C.
[0028] The process control computer 6 performs defective process indexing processing in which the manufacture process which the defect generated based on the memorized information is deduced while memorizing the defective name information that it inputs from a host computer 1, to an internal memory.
[0029] Next, operation of this example constituted as mentioned above is explained. It is made to learn so that the output pattern which first expresses a specific defective name to the input of defective information with the neuro-processing unit 5 may be generated. As shown in drawing 4 , as for the neuro-processing unit 5, the signal impressed to two or more neurons which constitute the input layer is outputted from two or more neurons which constitute an output layer, after Load W is imposed, while being transmitted to the output layer from the interlayer and the interlayer from the input layer. An output pattern which is different if Load W changes even if an input configuration is the same will be generated. This means that a desired output pattern is obtained to a certain input configuration, if the size of each load W is adjusted.
[0030] Here, defective A-J generated in a manufacture process and false defective A-C were mostly

decided according to the defective information (measurement conditions and the kind of analyte are included) expressed with the above-mentioned data structure. Therefore, as shown in drawing 5 , the defective information on Defect A is impressed to the input layer of the neuro-processing unit 5 according to an item. A difference with the teacher signal of the output pattern which appeared in the output layer at this time, and the pattern showing Defect A is searched for, and correction is added to each load of the neuro-processing unit 5 based on the difference searched for. The neuro-processing unit 5 is adjusted to the load W which generates the output pattern which expresses Defect A to the input of the defective information on Defect A by repeating this processing. Processing with the same said of other defective names and false defective names is repeated.

[0031] In the initial stage of study, even if it is in the optimal load state to a certain defective name, to other defective names, it is not in a suitable load state in many cases. However, it will be in the optimal load state to all defective names and false defective names by repeating the study about defective A-J and false defective A-C.

[0032] Next, if an operator directs an inspection start with the kind of analyte S with a keyboard 14, the conditions applicable to the analyte S will be read into a host computer 1 out of the verification condition beforehand saved in memory 15, and the optical-system control section 16 will set up optical system through a sequencer 4. Next, the analyte S of the 1st sheet is taken out from a stocker by the conveyance section, and it positions so that an inspection start point may come in the center of an observation visual field.

[0033] Next, an illumination system is driven and incorporation of an inspection picture is performed. In the interference optical system of the inspection picture input device 2, as shown in drawing 3 , the light of the halogen lamp 22 fixed in the lamp house 11 passes along a heat absorbing filter 23, and carries out outgoing radiation in the state of the parallel flux of light from the condensing lens 24 prepared in the outgoing radiation aperture of a lamp house 11. The rotation electrode holder 25 with which two or more narrow-band interference filters (not shown) were stored in the injection side of a condensing lens 24 is arranged. Rotation of the rotation electrode holder 25 is attained by the motor (not shown), and it can insert a desired interference filter into an optical path. The flux of light which passed the interference filter inserted into the optical path is condensed by the end face of an optical fiber bundle 27 with a condenser lens 26. The flux of light which carried out outgoing radiation of the optical fiber bundle 27 serves as the secondary light source which had intensity distribution equalized with the diffusion board 28. The diffusion board 28 is installed on the focal plane of a collimator lens. It reflects by the one-way mirror 31, and the flux of light which the diffusion board 28 was passed [ flux of light ] and had the diameter of the flux of light adjusted with drawing 29 turns into the parallel flux of light by the collimator lens 32, and carries out vertical incidence to Analyte S.

[0034] The flux of light reflected by Analyte S serves as convergence light through a collimator lens 32 again, and the component which passed the one-way mirror 31 carries out incidence to the image formation lens 33 of a zoom formula. This image formation lens 33 carries out image formation of the image of an analyte S front face on the image pck-up side of the image pck-up element 34.

[0035] Boards 35 and 36 have prevented that the image which the unnecessary object was illuminated by the lighting light which penetrated the one-way mirror 31, and was superimposed on the analyte image is projected on the image pck-up element 34. Moreover, in the slanting lighting optical system of the inspection picture input device 2, as shown in drawing 3 , the light source section 37 carries out incidence of the white flux of light to the optical fiber bundle end face of the line lighting section 38. The line lighting section 38 is what arranged each fiber in an optical fiber bundle in in the shape of 2 train straight lines by the outgoing radiation side, combines with the semicircle pilaster-like condenser lens 39, and builds the lighting light of the shape of a thin sheet. In addition, the detection sensitivity anisotropy of the defect which was installing four sets of the line lighting sections 38 in the symmetric position so that it might become in the same direction of incidence to Analyte S, compensated mutually, and illuminated the inside of an observation visual field to homogeneity mostly, and had the directivity of an analyte S front face is compensated.

[0036] Through a collimator lens 32 etc., on the image pck-up element 34, image formation of the image

of the analyte S illuminated in the line lighting section 38 is carried out, and it is picturized. If it is necessary to prevent attenuation of the feeble scattered light, a one-way mirror 31 will be moved in the direction perpendicular to space by the parallel displacement stage (not shown), and it will be made to remove from an observation optical path.

[0037] Moreover, in the diffraction optical system of the inspection picture input device 2, as shown in drawing 3 , from the diffracted-light generation section 40, incidence of the flux of light which carried out outgoing radiation is carried out to a collimator lens 32, and it carries out incidence to it at right angles to Analyte S. The reflected light of Analyte S passes the KOREMETA lens 32 and a one-way mirror 31, and is projected on the image pck-up element 34.

[0038] Three kinds of above illumination systems are properly used according to the content of inspection of a defect. When carrying out defective inspection resulting from thickness nonuniformity, an interference optical system is used, and when inspecting distortion of the diffraction pattern of Analyte S, silverfish, etc., diffraction optical system is used. Moreover, in inspecting the crack of Analyte S, and dust, it uses slanting lighting optical system.

[0039] On the other hand, an image processing system 3 incorporates an inspection picture from the image pck-up element 34 by control of a host computer 1. If the image pck-up element 34 is read from an image processing system 3 and a timing signal is received, it will carry out photo electric translation of the inspection picture of the analyte S projected on the image pck-up side, will incorporate it, and will input it into an image processing system 3. In an image processing system 3, the image processing of an inspection picture is performed and defects, such as thickness unevenness and dust, are extracted. Next, only the defective part extracted to the inspection picture carries out emphasis processing, and binary--ization-processes the picture further. Next, labeling processing is performed to each defective part extracted by binary-ized processing, and label attachment is carried out to each defective part. The area, a boundary length, Ferre, circularity, and the center-of-gravity address are searched for about each defective part by which label attachment was carried out. Each [ these ] data is sent to a host computer 1. In addition, an inspection picture and a processing picture are displayed on a monitor 12 if needed, and an inspection picture and a processing picture are saved at the picture storage 11.

[0040] a host computer 1 reads the defective information on each defective part by which label attachment was carried out (area, a boundary length, Ferre, circularity, center-of-gravity address, etc.) from an image processing system 3, reads measurement conditions (the content of a setting of optical system, image-processing method) from memory 15 further, and are these ****** -- it is made the data structure which combined information and inputs into the neuro-processing unit 5

[0041] If the defective information on the data structure shown in drawing 2 inputs, the neuro-processing unit 5 will deduce a specific defective name from all the input conditions of input data, and will generate the output pattern showing the defective name. For example, when Defect A is deduced, only the neuron of the defect A in an output layer is ignited. The defective name judged in the neuro-processing unit 5 is inputted into a host computer 1.

[0042] A host computer 1 is sent out to the process control computer 6 while it will display the defective name on a monitor 13, if the defective name judged from the neuro-processing unit 5 is inputted. Moreover, the host computer 1 classifies the defective data for every analyte exception and manufacture process, and analyzes the generating trend of a defect by statistical processing while it accumulates the defective name. If the threshold which prepared this analyzed generating trend in the graph of graph-ized Perilla frutescens (L.) Britton var. crispa (Thunb.) Decne. is exceeded, alarm will be outputted and defective generating will be announced beforehand.

[0043] In addition, when a new defect is discovered, the defective information about the defect is analyzed, the defective information about the new defect is created, and the neuro-processing unit 5 is made to learn for the defective information.

[0044] By process control computer 6, if a defective name is inputted from a host computer 1, the process which the defect generated based on the defective name is specified. And while stopping a defective generating process, the analyte which hung control on the process process and was judged to be a defect is returned to reprocessing steps.

[0045] Thus, since it had the neuro-processing unit 5 made to learn by the teacher signal showing the defective name used as the defective information which consists of a kind of this example ******, the information acquired from the defect on the front face of an analyte, and defective detection optical system, an image-processing method of defective detection, etc., and such defective information, the classification of a defect can judge automatically from the defective information on a defective part, and quick feedback in the manufacture process which the defect generated is attained. Consequently, the defect to generate can be pressed down to the minimum. And since judgment can set up the measurement result and measurement conditions of difficult a large number even if it is the skilled operator, a defective classification judging result with high repeatability can be obtained. Moreover, since the neuro-processing unit 5 was made to learn the false defect which is discriminable only by human being, the automatic judging of a false defect was attained.
[0046] The defective classification information judged in this example ****** and the neuro-processing unit 5 was accumulated one by one, and prior prediction of defective generating was attained by processing serially statistically the defective generating frequency for every defective generating place or process which can be found according to defective classification.
[0047] In addition, in the above-mentioned example, although prior prediction of defective generating is performed by process control computer 6, you may be made to perform same processing with a host computer 1. In this case, the defective classification information judged in the neuro-processing unit 5 is serially stored in memory 15, and it is made for a host computer 1 to read if needed. Deformation implementation is variously possible for this invention within limits which are not limited to the above-mentioned example and do not deviate from the summary of this invention.
[0048]
[Effect of the Invention] Without depending on experience of the skilled operator according to this invention, as a full account was given above, the classification of the defect which related to the defective generating process or the defective generating cause closely can be judged automatically, and a manufacture process can be provided with the defective classification judging equipment and the process control system which can be fed back for a defective inspection result quickly and correctly.

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[Translation done.]